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ARTICLES Page

REFERENCE INFORMATION

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THE EDITOR'S NOTES

Longer Articles. One or two of our readers have told us that the articles we publish are too short. In this issue we devote nearly ten pages to an article by E. L. Gruenberg of about 6000 words; this article seems to us thoughtful, penetrating, and important; and although it is twice as long as our usual longest article, we think it should be published.

Comments on this article (and on any other information that we publish) are invited from any reader who feels inclined to comment. We desire to be of service to our readers.

Who's Who, 1954 Compilation. We are considering publishing "Who's Who in Computers and Automation" 1954, in a single alphabetical list.

If any reader, since the time his entry was published last year, has any changes to report, in address, affiliation, title, interests, etc., now is the time for him to report them to us. A style of form for the Who's Who entry appears on page 33.

Roster of Automatic Computing Services. In this issue we begin a new piece of reference information: a roster of organizations which offer computing services and which possess an automatic computer either digital or analog. We shall be grateful for any additions or corrections which any reader is able to send us.

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Address Changes. If your address changes, please notify us giving both old and new addresses, and allow three weeks for the change.

Back Copies. See the information on page 31.

Manuscripts. For manuscripts wanted see the note on page 10.

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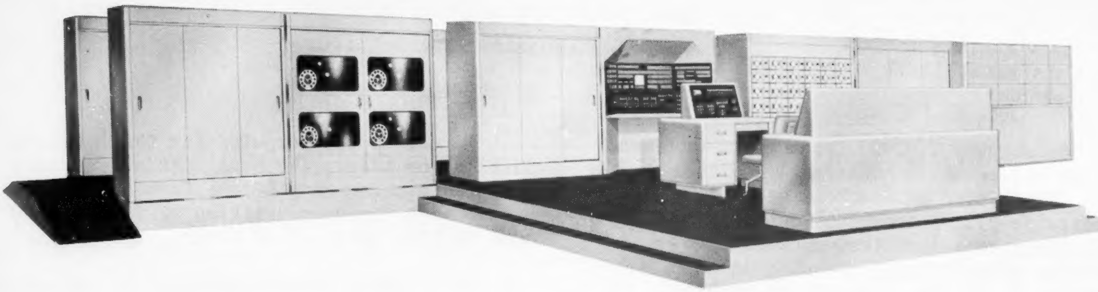

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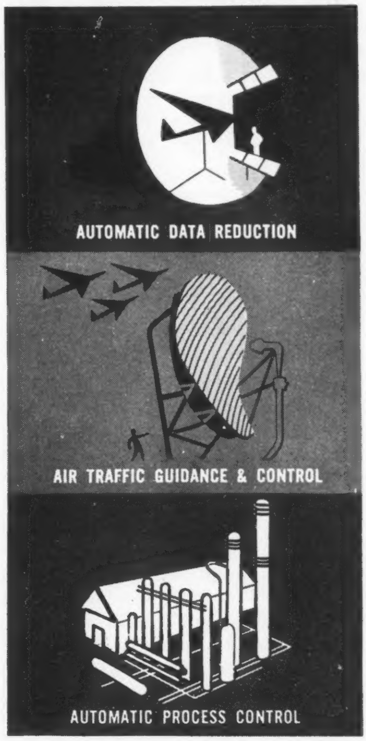

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LANGUAGE TRANSLATION BY MACHINE —

A REPORT OF THE FIRST SUCCESSFUL TRIAL

Neil Macdonald

On January 7, 1954, at a press conference in the office of International Business Machines Corporation in New York, the IBM 701 electronic data processing machine located there presented the first successful demonstration of meaningful translation from one language to another language by machine. Although this demonstration was simply a trial of machine translation, involving a vocabulary of only a few hundred Russian and English words, its success is full of significance and exciting promise for the future.

The success was due to a year and a half of cooperative effort by the Institute of Languages and Linguistics of Georgetown University, Washington, D. C., and the IBM Corporation. On the part of the Institute, those most concerned with the achievement were Dr. Leon Dostert, Director of the Institute, planner, organizer, and sparkplug of the project, and Dr. Paul Garvin, linguist in twelve languages, and main architect of the linguistic translation scheme. On the part of IBM, those most concerned were Dr. Cuthbert C. Hurd, Director of the Division of Applied Science, Mr. Peter Sheridan, mathematician and composer of the IBM 701 program which accomplished the translation, and Mr. Thomas J. Watson, Chairman of the Board of IBM, who authorized and encouraged the research project.

The Nature of the Trial

A total vocabulary consisting of 250 Russian words (in latinized spelling) relating to the fields of politics, law, mathematics, chemistry, metallurgy, communications, and military affairs was punched on punch cards. Associated with each Russian word and punched on the same card were one or two English equivalent words, and three codes designated as 1st, 2nd, and 3rd. These codes (linguistically they can be considered "diacritical marks") together with the program caused appropriate translation. For example, different meanings of words could be selected. The order of words in Russian could be left unchanged or could be altered in a specified way, as might be indicated. A word could be treated as a whole or could be divided into a root and a suffix. And so forth.

An extract from the dictionary is shown on page 10.

To set up the computer for the language translation trial, the punch cards were run into the machine and their information stored on the magnetic drums, taking up the space of 6000 machine words of 36 binary digits each.

Next, the program developed for purposes of translation was run into the machine. This program consisted of about 2400 program steps or instructions. The general scheme of the program is shown in Figure 1, Dictionary Syntax Flow Chart.

Finally, a number of Russian sentences staying within the vocabulary and the linguistic constructions planned for, were given to the machine. With about 5 to 8 seconds of machine computation for each one, the output printer of the IBM 701 proceeded to write out translations of the sentences. Examples follow:

KACHYESTVO UGLYA OPRYEDYELYAYETSYA KALORYIYNOSTJYU
  The quality of coal is determined by calory content.

KRAXMAL VIRABATIVAYETSYA MYEXANYICHYESKYIM PUTYEM YIZ KARTOFYELYA
  Starch is produced by mechanical methods from potatoes.

VYELYICHYINA UGLA OPRYEDYELYAYETSYA OTNOSHYENYIYEM DLYINI DUGI K RADYIUSU
  Magnitude of angle is determined by the relation of length of arc to radius.

OBRABOTKA POVISHAYET KACHYESTVO NYEFTYI
  Processing improves the quality of crude oil.

MI PYERYEDAYEM MISLYI POSRYEDSTVOM RYECHYI
  We transmit thoughts by means of speech.

ZHYELYEZO DOBIVAYETSYA YIZ RUDI XYIMYICHYESKYIM PROTSYESSOM
  Iron is obtained from ore by chemical process.

VOYENNIY SUD PRYIGOVORYIL SYERZHANTA K LYISHYENYIYU GRAZHDANSKYIX PRAV
  A military court sentenced a sergeant to deprival of civil rights.

VLADYIMYIR YAVLYAYETSYA NA RABOTU POZDNO UTROM
  Vladimir appears for work late in the morning.

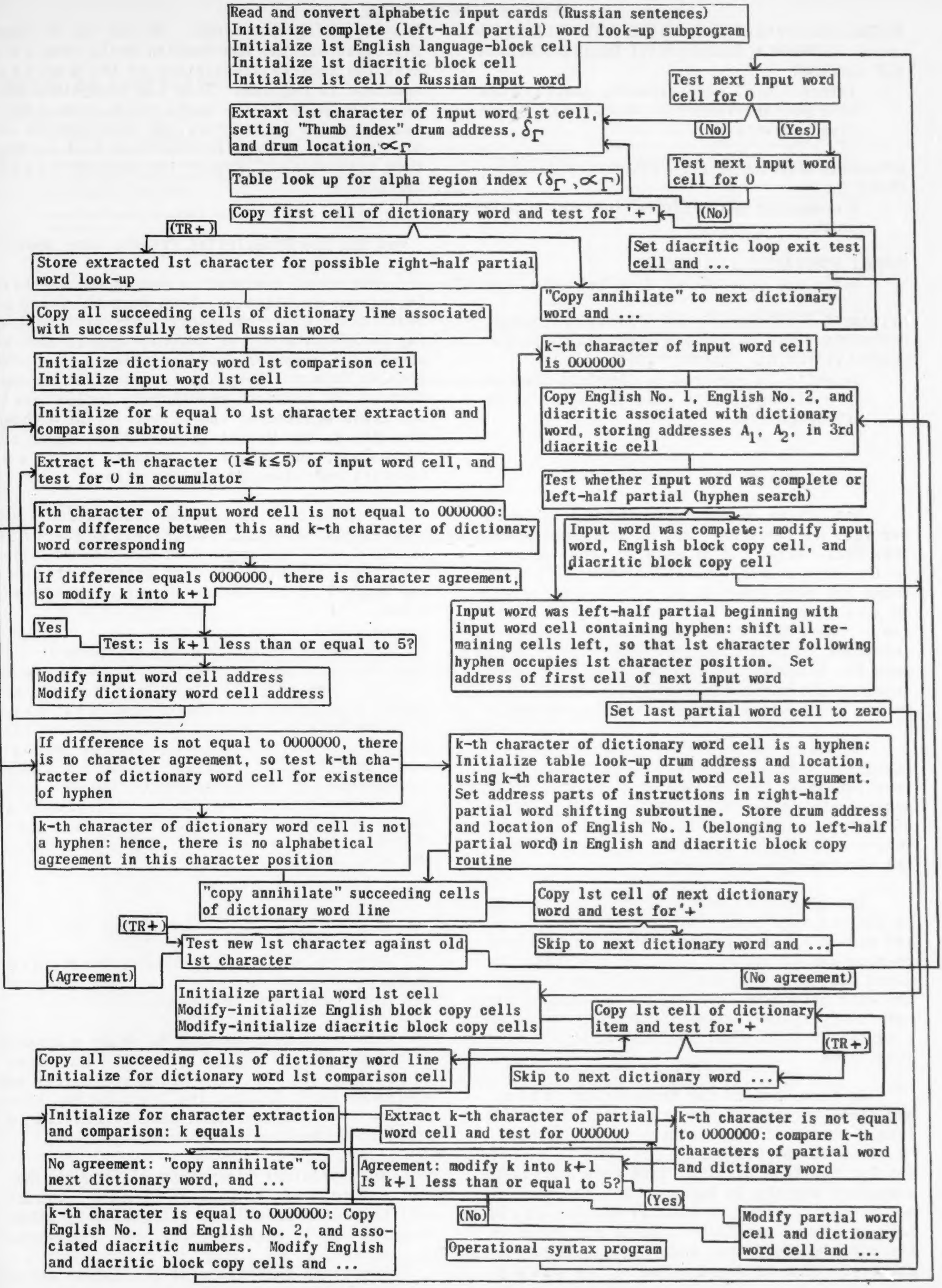

Figure 1 — Dictionary Syntax Flow Chart

MYEZHDUNARODNOYE PONYIMANYIYE YAVLYAYETSYA VAZHNIM FAKTOROM V RYESHYENYIYI POLYITYICHYESKYIX VOPROSOV
International understanding constitutes an important factor in decision of political questions.

KOMANDYIR POLUCHAYET SVYEDYENYIYA PO TYELYEGRAFU
A commander gets information over a telegraph.

DOROGI STROYATSYA YIZ BYETONA
Roads are constructed from concrete.

DYINAMYIT PRYIGOTOVLYAYETSYA XYIMYICHYESKYIM PROTSYESSOM YIZ NYITROGLYITSYERYINA S PRYIMYESJYU YINYERTNIX SOYEDYINYENYIY
Dynamite is prepared by chemical process from nitroglycerine with admixture of inert compounds.

How Do the "Codes" Work?

Now it can be seen from the discussion so far that an important part of the success of this first trial run of machine translation is the way in which the codes work. They cause words and word order to be selected and arranged according to six "rules of operational syntax". These six rules are stated in Figure 2, and under them is shown the way in which they work for a sample Russian sentence, which when translated is "magnitude of angle is determined by the relation of length of arc to radius".

According to Dr. Dostert, the rules of operational syntax that would be required for the translation of any Russian sentence into English might number a hundred; but for great numbers of sentences, and in particular for all the sentences of the type included in the experiment, the six rules were sufficient.

The effect of the codes and the rules is to fix the alternative meanings of the word, and enable the machine to determine the right meaning out of several possible meanings. The codes take into account the sentence structure, the word structure, the nature of the prefixes and suffixes, the context, etc.; they recognize a series of structural patterns or syntactic structures.

In fact, before the translation scheme was given to the IBM 701 programmers to convert into a series of instructions to the machine, Dr. Dostert and Dr. Garvin got hold of people who did not know Russian, gave them Russian sentences written in Roman characters, and a set of cards. The non-Russian speaker would look at a word and look it up in his cards. In his cards he found the word and instruction numbers. Then he would refer to the cards bearing the instructions. At the end of about five minutes, the non-Russian would come out with the correct translation of the Russian sentence in English. Then the Georgetown men knew they were on the right track, because they had succeeded in reducing the whole process to the capacity to read instructions and carry them out, which of course the machine could perform.

How Did the Translation Project Come About?

For about ten years a number of scholars in various institutions have been thinking as individuals about the possibility of formulating an adequate set of instructions so that an electronic computer would be able to transfer meaning from one language into another language. Much of the research was largely conjectural. Dr. Erwin Reifler of the University of Washington, Dr. Y. Bar Hillel then at Mass. Inst. of Technology, and others, formulated various theories and advanced various plans.

A conference on machine translation took place at MIT in June, 1952. This conference was held with the support of the Rockefeller Foundation and with the very active interest and support of Dr. Warren Weaver of the Foundation.

Dr. Dostert attended the conference; he went there rather skeptical about the whole idea, but came away convinced that the only way to put an end to many hypothetical disputes would be to try to make a simple, yet not too extensive, test of the feasibility of mechanical translation. After discussing it with some of his associates in Georgetown, he took the subject to IBM, and there met a sympathetic and helpful reception. Thus the project was launched, in terms of trial with a glossary of 250 Russian words.

What Will the Project Lead to?

Many exciting possible developments are indicated by the success of the trial, according to Dr. Hurd and Dr. Dostert.

Linguists will be able to study a language in the way that a physicist studies material in physics, with very few human prejudices and preconceptions, because the language has to be reduced to its operational characteristics in order to be handled electronically.

The technical literature of Germany, Russia, France, and the English-speaking countries will be made available to scientists of other countries as it emerges from the presses.

Technical know-how will be rapidly avail-

Rules of Operational Syntax

RULE 1: REARRANGEMENT

If first code is '110', is third code associated with preceding complete word equal to '21'? If so, reverse order of appearance of words in output (i.e., word carrying '21' should follow that carrying '110')—otherwise, retain order.

In both cases English equivalent I associated with '110' is adopted.

RULE 2: CHOICE—FOLLOWING TEXT

If first code is '121', is second code of the following complete, subdivided or partial (root or ending) word equal to '221' or '222'? If it is '221', adopt English equivalent I of word carrying '121'; if it is '222', adopt English equivalent II.

In both cases, retain order of appearance of output words.

RULE 3: CHOICE—REARRANGEMENT

If first code is '131', is third code of preceding complete word or either portion (root or ending) of preceding subdivided word equal to '23'? If so, adopt English equivalent II of word carrying '131', and retain order of appearance of words in output —if not, adopt English equivalent I and reverse order of appearance of words in output.

RULE 4: CHOICE—PREVIOUS TEXT

If first code is '141', is second code of preceding complete word or either portion (root or ending) of preceding subdivided word equal to '241' or '242'? If it is '241', adopt English equivalent I of word carrying '141'—if it is '242' adopt English equivalent II.

In both cases, retain order of appearance of words in output.

RULE 5: CHOICE—OMISSION

If first code is '151', is third code of following complete word, or either portion (root or ending) of following subdivided word equal to '25'? If so, adopt English equivalent II of word carrying '151' —if not, adopt English equivalent I.

In both cases, retain order of appearance of words in output.

RULE 6: SUBDIVISION

If first code associated with a Russian dictionary word is '***', then adopt English equivalent I of alternative English language equivalents, retaining order of appearance of output with respect to previous word.

SOURCE SENTENCE: vyelyichyina ugla opryedyelyayetsya otnoshyenyiyem dlyini dugi k radyiusu.

ANALYSIS:

RUSSIAN WORD	ENGLISH EQUIVALENTS I	ENGLISH EQUIVALENTS II	1st CODE	2nd CODE	3rd CODE	RULE NO
vyelyichyina	magnitude	---	***	***	**	6
ugl-	coal	angle	121	***	25	2
-a	of	---	131	222	25	3
opryedyelyayetsya	is determined	---	***	***	**	6
otnoshyenyi-	relation	the relation	151	***	**	5
-yem	by	---	131	***	**	3
dlyin-	length	---	***	***	**	6
-i	of	---	131	***	25	3
dug-	arc	---	***	***	**	6
-i	of	---	131	***	25	3
k	to	for	121	***	23	2
radyius-	radius	---	***	221	**	6
-u	to	---	131	***	**	3

TARGET SENTENCE: magnitude of angle is determined by the relation of length of arc to radius.

Figure 2 -- Rules of Operational Syntax, and a Sample Sentence Translated

able to the under-developed areas of the world, such as Pakistan, Indonesia, Yugoslavia, the Arab world, in their own languages. Divisions of the U. S. Government may well be interested in picking up and carrying forward this development.

A problem in an entirely new field of the social sciences has been solved.

Information from this experiment will be of considerable use in the design of information-handling machinery particularly adaptable to language translation.

But of course it must be emphasized that a vast amount of work is still needed, to render mechanically translatable more languages and wider areas of a language. For 250 words and 6 syntactical structures are simply a "Kitty Hawk" flight.

EXTRACT FROM DICTIONARY

	English Equivalents:		1st	2nd	3rd
Russian Word	I	II	Code	Code	Code
k	to	for	121	***	23
kyislorodn-	oxygen	***	***	***	**
lyishyenyi-	deprival	***	***	222	**
matyeryial-	material	***	***	***	**
mi	we	***	***	***	23
mislyi	thoughts	***	***	***	**
mnog-	many	***	***	***	**
myedj	copper	***	***	***	21
myest-	place	site	151	***	23
myexanyichyesk-	mechanical	***	***	242	**
myezhdunarodn-	international	***	***	***	**
na	on	for	121	***	23
napadyenyi-	attack	attacks	121	***	**
nauka	a science	***	***	242	**
obrabotka	processing	***	***	***	**
obwyekt-	objective	objectives	121	***	**
ofyitsyer-	an officer	the officer	***	***	**
-ogo	of	***	131	***	23
-on	by	***	131	***	**
opryedyelyayet	determines	***	***	***	**
opryedyelyayetsya	is determined	***	***	***	**
optyichyesk-	optical	***	***	***	**
orudyiye	gun	***	***	241	**
otdyel-	section	***	***	***	**
otdyelyenyiye	division	squad	121	242	**
otnoshyenyi-	relation	the relation	151	***	**

<u>Manuscripts</u>. We desire to publish articles that are factual, useful, understandable, and interesting to many kinds of people engaged in one part or another of the field of computers and automation. In this audience are many people who have expert knowledge of some part of the field, but who are laymen in other parts of it. Consequently, a writer should seek to explain his subject, and show its context and significance. He should define unfamiliar terms, or use them in a way that makes their meaning unmistakable. He should identify unfamiliar persons with a few words. He should use examples, comparisons, analogies, etc., whenever they may help readers to understand a difficult point. He should give data supporting his argument and evidence for his assertions. An article may certainly be controsial if the subject is discussed reasonably. Ordinarily, the length should be 1000 to 4000 words, and payment will be $10 to $50 on acceptance. A suggestion for an article should be submitted to us before too much work is done. To be considered for any particular issue, the manuscript should be in our hands by the 5th of the preceding month.

ROSTER OF AUTOMATIC COMPUTING SERVICES

(Information as of January 10, 1954)

The purpose of this Roster is to report organizations (all that are known to us) offering automatic computing services and having at least one automatic computer, either analog or digital. Each Roster entry contains: name of the organization, its address / analog or digital computation provided / notes on equipment / any restrictions as to clients.

We shall be grateful for any additions or corrections that any reader is able to send us.

Some of the abbreviations are as follows:

A	analog	anal	analyzer
D	digital	diff	differential

govtO primarily available to government agencies or contractors only

CPC IBM card programmed calculator

ROSTER

Askania Regulator Co, 240 East Ontario St, Chicago 11, Ill / A / Philbrick

Battelle Memorial Inst, 505 King Ave, Columbus 1, Ohio / A, D / diff anal, CPC, punch card

Burroughs Adding Machine Co, 511 No Broad St, Philadelphia 23, Pa / D / Burroughs Laboratory Computer

Computer Research Corp, 3348 West El Segundo Blvd, Hawthorne, Calif / D / Cadac 102A, etc

Engineering Research Associates, Division of Remington Rand, 555 23rd St South, Arlington 2, Va / D / ERA 1101

General Electric Co, Schenectady, N.Y. / A / network anal AC and DC, diff anal

The George Washington University, Logistics Research Project, 707 22nd St, Washington, D C / D / ONR automatic relay computer

Financial Publishing Co, Mathematical Tables Div, 82 Brookline Ave, Boston 15, Mass / D / CPC's, punch card

Harvard Computation Laboratory, Harvard University, Cambridge 38, Mass / D / Harvard IBM Mark I, Harvard Mark IV

International Business Machines Corp, 590 Madison Ave, New York, N Y, and elsewhere / D / IBM 701, 650, 604, CPC, punch card, etc

Mass Inst of Technology, Center of Analysis, Cambridge 39, Mass / diff anal, punch card

Moore School of Electrical Engineering, 200 South 33 St, Phila 4, Pa / A, D / diff anal, CPC, punch card

National Bureau of Standards, Applied Mathematics Laboratory, Washington, D C / D / Seac, Dyseac, punch card / govtO

National Bureau of Standards, Institute for Numerical Analysis, 405 Hilgard Ave, Los Angeles 24, Calif / D / Swac, etc

Northrop Aircraft, Inc, Director of Computing, Hawthorne, Calif / A, D / CPC's, Maddida, Binac, punch card, etc

G A Philbrick Researches, Inc, 230 Congress St, Boston 10, Mass / A / Philbrick

Purdue Univ, Dept of Math, Lafayette, Ind / D / CPC, punch card

Raytheon Mfg Co, Computing Services Section, Waltham, Mass / D / automatic electronic digital computer, etc

Reeves Instrument Co, 215 East 91 St, New York, N Y / A / Reac

Remington Rand, Inc, 315 4th Ave, New York, N Y/ D / Univac, punch card, etc

Scientific Computing Service, Ltd, 23 Bedford Sq, London W C 1, England / D / -

Swedish Board for Computing Machines, Drottningatan 95A, Stockholm, Sweden / D / Bark, Besk

Telecomputing Corp, 133 East Santa Anita Ave, Burbank, Calif / A, D / IBM punch card, CPC's, automatic graph readers, digital plotters

U S Air Force, Computation Research Section, Wright Air Development Center, Wright Patterson Air Force Base, Dayton, Ohio / A,D / CPC's, Reac's, punch card / govtO

U S Army, Ballistic Research Laboratories, Aberdeen, Md / D / Ordvac, Edvac, Eniac, Bell Model V, CPC, punch card / govtO

U S Navy, Naval Proving Ground, Dahlgren, Va / D / Harvard Mark II, Harvard Mark III, punch card / govtO

University Mathematical Laboratory, Free School Lane, Cambridge, England / D / Edsac

University of Michigan, Willow Run Research Center, Ypsilanti, Mich / D / Midac, etc

Univ of Toronto, Computation Centre, Toronto, Ont, Canada / D / Ferranti

Univ of Wisconsin, 306 North Hall, Madison 6, Wisc / A, D / Philbrick, CPC, punch card

Wayne University, Computation Laboratory, Detroit 1, Mich / A, D / diff anal, Burroughs Unitized Digital Electronic Computer, etc

Westinghouse Electric Corp, Industry Engineering Dept, East Pittsburgh, Pa / A, D / Anacom, network anal AC and DC, punch card

REFLECTIVE THINKING IN MACHINES

by E. L. Gruenberg,

W. L. Maxson Corporation, New York

The possibility that thinking may occur in machine-like devices has caught the imagination of psychologists, engineers, mathematicians, and the readers of science fiction. (1,2,3) Much controversy exists as to whether the activity in modern computing machines can be considered thinking, or at least equivalent to the mental activity carried on by human beings. Often it seems to be taken as axiomatic by those who speculate on this subject that creating machines that could ape human thinking would be desirable. Yet little attention is paid to considering what possible gain might accrue from the use of such machines as opposed, for example, to what might be achieved by designing machines solely to perform repetitive operations in computation.

Much of the disagreement on the subject stems from the use of differing definitions. E. C. Berkeley (4) maintains, "a machine can handle information, calculate, conclude, choose, perform reasonable operations with information. A machine, therefore, can think." This definition appears too broad for M. V. Wilkes (5) since by a reasonable interpretation of this definition one can conclude that an automatic block signal can think. Mr. Wilkes then decides that imitation of human behavior is a better standard of thinking and uses this as his definition. In all fairness, it should be pointed out that later on in his book, Mr. Berkeley states that machines cannot yet do creative thinking.

Perhaps some of the difficulty arises from not adopting a specific definition that will mark out the kind of human thinking of most value. The kind of thinking of greatest value to human beings is reflective thinking. This is the kind of thinking that is used to change doubtful into settled situations.

Let us turn to the philosopher John Dewey (6,7) for a definition of reflective thinking: "It is that operation in which present facts suggest other facts in such a way as to induce belief in what is suggested on the ground of real relation in the things themselves." (6,7) Wherever and whenever human beings are faced with recognizing and solving problems, this type of intellectual activity will be found. Basically it is such thinking which has extended civilization and made scientific advances, and which is essential to the carrying on of business and government. Exercise of this thought process is what gives man an ever widening control of the world. It is a purpose of this article to determine whether machines can do reflective thinking.

John Dewey made a masterful analysis (6) of this kind of thinking with the aim of improving methods of teaching. From his viewpoint, the objective of teaching should be the stimulating of reflective thinking in human beings, particularly children. In his book, "How We Think", an interesting picture of the process of reflective thought can be found. Let us then speculate on the following questions:

1. Can each step of the process of reflective thinking be performed by a machine working on principles now understood?

2. If each such step can be performed, can a single machine do reflective thinking?

3. Would it be desirable to construct such a machine? What would be gained?

4. How would such a machine differ from human beings? Would it be able to acquire human experience?

Our method of approaching these questions will be first, to set forth the characteristics of the process of reflective thinking as it is understood to exist in human beings; then, to determine whether such a process could be carried out by man-made machines; and finally, to consider the possible consequences of such an achievement.

The Raw Material of the Thought Process

To begin with, thinking in human beings proceeds from raw ideas or suggestions which occur spontaneously. This implies that human

beings do not have full control of their own thinking process. It is true that the mind cannot be stopped by its owner: "The human understanding is unquiet; it cannot stop or rest; and still presses onward, but in vain". (8) The raw ideas or suggestions arise from the experience of the individual and result from an association with an object, causality, or event.

This lack of control of the thought process is a fundamental stumbling block to the training of the human mind to think. If individuals cannot control their own minds, how can one individual train another's mind? The answer is that the conditions that give rise to the raw ideas, the suggestions, can be controlled; the events or objects which most likely will lead to the suggestions can be placed before the individual. His thinking can be directed but his thought process cannot be controlled.

The ability to think is greatly influenced by the range, depth, and speed of the suggestions which occur to the individual when subject to the underlying situations. These also are factors not entirely under control of the individual.

The suggestions which arise out of the experience of the individual must be in terms meaningful to him. Two phenomena enhance the acquiring of meanings by the individual; they are concepts and language. Concepts are meanings which have become standardized. They can be reused with assurance, and can be related to a system. The function of language is to select, preserve, and apply specific meanings. Words act (1) to delineate or fence off meanings, (2) to identify them, and (3) to carry or communicate them.

The process of forming suggestions into concepts constitutes the learning process of the individual. For at the start of the human being, all things are vague, hazy, and doubtful: the child only gradually achieves mastery over his body and only gradually achieves awareness of the world around him, as he increases his store of concepts.

If the thinking machine we propose to construct — or at least outline — is to resemble the human thinking being, it will have to possess six basic characteristics of the process of reflective thought.

First, there must exist a way of sensing objects and events. This sensing activity is meant in the broadest sense. It includes the ability to sense light, temperature, the size of objects and the occurrence of these phenomena in terms of time.

Second, there must exist a way of storing sensations; this is memory. In other words the machine must have a way of acquiring experience.

Third, responses within the machine would be evoked automatically upon the reception of sensations. These are the suggestions or raw ideas.

Fourth, the responses and sensations would be formed in terms of a language, so that the sensations would acquire meaning and could develop into standardized meanings or concepts.

Fifth, the machine would possess the ability to recognize similarities and differences in new situations compared with situations already stored in its experience. In this way the machine could acquire new concepts. This process repeated over and over will enable it to learn.

Sixth, for the machine to be useful, or at least to be recognized as a thinking entity, the machine must possess a way of communicating results of thought to the outside world in some manner intelligible to human beings.

What about emotions? Emotional drives are basic to all human activity. As John Morley puts it in his book, "Rousseau", "All good things come from the heart, but must go through the head." This is an eloquent way of saying that the best employment of our feelings is to start the thinking process going. Probably Lindbergh did not rationally choose flying; he did so to satisfy a desire for adventure, and because of the thrills associated with the flying experience. But emotions are not part of the thinking activity. We can conceive of machines, having only the above six attributes, being able to do rational thinking without the motivating drive of emotions. They will automatically process appropriate data they take in by way of their sensations and with no other drive but electric power.

Do Computers Possess the Essential Elements for Thinking?

Let us pause briefly to consider how many of these attributes are possessed by modern computing machines.

All such machines possess sensing elements of some kind. In the case of high-speed digital computers however, almost all such sensations are prepared for it by the programmer. In the case of the IBM 701 data processor, for example, the programmer converts the events and data into a sequence of commands which are recorded on punched cards and sometimes on mag-

netic tape. This particular machine can have suggestions only in terms of pulses originating in this fashion. There are other digital machines which can sense the contour of an object which is to be copied or sense a curve printed on paper and use this information to control a milling machine which will cut this curve. We can say that computing machinery at present can sense objects and events but only in a limited fashion. This means that if they do think they must think as specialists. It appears possible in the future for such devices to sense the human voice in a manner intelligible to the machine. When this occurs, their field of thinking would be broadened.

The second attribute is the means of storing sensations and acquiring experience. A major component of modern digital computing machines is memory. High-speed storage is used to assist in the momentary computing operation which is demanded of the machine from the "suggestions" received from the punched card or other sensing element. Long-term storage is required for sensations which are expected to be useful in many situations in the future. Because of space limitations, not all such sensations can be permitted to be retained at the machine. For this reason the accumulation of experience by the present computing machine is rather limited. To enhance it, magnetic tape libraries are resorted to.

High-speed digital computing machines such as the IBM 701, Univac, and SEAC, do not respond to sensations automatically but require commands or instructions to direct them how they should respond. Special purpose machines however, do respond to specific sensations of a very limited kind and range in an automatic and precise way. The automatic milling machine is an example. Many automatic navigational computers act in the same fashion. Hence, it must be conceded that present-day computers suffer from two serious drawbacks in their usefulness for thinking processes: (1) the kind of response to sensations must be commanded of them, or (2) the range of response to sensation is limited when the kind of response is automatic.

The first limitation cannot be considered inherent in the machines but one imposed upon them by the designers. If the object of the machine is to save repetitive operations for the human calculator, then it is convenient to employ a slave which will follow an established program of instructions. Thus, the current direction of progress in automatic programming techniques has not been to eliminate this master-slave relationship but rather to reduce the number of commands (5,9). Reflective thinking cannot be done by an entity tied down by such thought control.

An interesting commentary on the second drawback is afforded by the example of the intelligence of birds. Birds, as pointed out by Huxley (10), represent the culmination of a separate line of evolutionary development compared with that which has resulted in man. In the case of birds, emphasis was placed by evolution upon automatic control, or instinct; whereas in man the development of a large memory containing 10^{10} nerve cells occurred. The frontal part of the brain which contains conscious memory has not developed in birds. Hence they do not rely on experience and learning but do everything instinctively. They fly by instinct (automatic control); they build their nests this way. Huxley cites examples of birds which see their nests only briefly when young and yet when they mature, build then exactly as did their parents. Experiments show that migration in birds is automatically controlled by the amount of daylight they are exposed to. Birds are literally the prototype of present-day guided missiles. Given sensations outside of those which operate their controls, they give no reasonable response.

In regard to the third attribute, responses and sensations are formulated in terms of a language in digital machines. It is true that this language rests upon a system of numbers, but it is conceivable that certain combinations of data may grow to have standardized meanings to the machine. It may be that such machines can form concepts in a much clearer and more dependable fashion than human beings since their coding system would rest on more logical grounds and their means of standardizing meanings would be emotionless and precise. A possible advantage of a number language is that the meaningful words may be formed by summing, multiplying, etc.

The next attributes relate to the ability to learn or form new concepts. Here too we find machines are lacking (5,10). Some reflection however, leads one to suspect that this lack is not inherent but stems from the aim of their designers. Computers have been designed to perform those routine operations required by complicated or difficult mathematical situations or control problems. The objective has been to overcome human drudgery, not to create an independent source of thought. Actually the possibilities of reducing human drudgery by building thinking entities are probably at least as large as those by designing routine machines. Consider that programming of problems for computing machines may take two months whereas the computing machine does the drudge in two minutes.

What are required are machines which are designed to be able to learn. (5,11)

Others such as Wilkes (5), Shannon (11), and Oettinger have recognized this need. It should be recognized that our concept of learning is somewhat broader than that employed by them. Learning as used here is the acquisition of meaning. To learn as Oettinger conceived it, was eventually to repeat automatically that which was approved by the instructor. Shannon's maze-solving mouse (11) learned by trial and error, but success was rewarded. Neither the element of approval or success are fundamental to learning, but meaning is.

For a device to learn, then, it should have internal mechanisms and circuits which are able to compare new sensations and sequences of sensations with previous ones and detect similarities. This activity must go on automatically as reception of sensation is received, and the storage of new concepts as recognized must be automatic. The machine must be able to override commands it receives when it has a concept stored in it, upon which it can rely with more confidence than the command itself. How all this might be done will be made clearer when we examine the thought process itself.

One simple computing machine devised by Bell Telephone Laboratory engineers did have the capacity to learn in a limited fashion. This was a relay device made specifically to play the game of tic-tac-toe. The machine stored sequences of moves it played in a game. If it lost on a certain sequence, the machine would store this fact. The machine would then remember never to use this sequence again. Since all this occurred automatically, the machine was learning by itself, and eventually had all the concepts necessary to always win the game.

In regard to the sixth attribute, the need for communication of results is evident. All machines must possess a data readout or a means of indicating solutions. However, there would need to be some indication of the accumulation of standard meanings in the device before it could be recognized as a thinking entity. Such recognition was possible in the tic-tac-toe machine since one was able to tell that it would not play the game in the same way once it had lost in that way. If the world of ideas were to be limited to tic-tac-toe, this machine could then be considered to be thinking. Shannon's maze-solving mouse, which always took the short path once it had found it, is another example.

The Thought Process

When a person faces a perplexing situation, the opportunity for reflective thinking arises. If he recognizes the need for changing this doubtful, vague or uncomprehended state of affairs into a settled and orderly one that fits into his framework of beliefs, he begins to reflect. Many individuals experience almost a physical discomfort when confronted with such situations and compelled to apply the process of reflective thought. Other people simply do not meet the challenge, perhaps from lack of related experience, or from torpor, or from lack of curiosity.

Once the challenge is consciously or instinctively accepted, the human being's thought process begins. He observes the facts, gathers data. Possible courses of action are suggested, but final judgment is suspended. This last is a telltale sign of reflection. The possibilities or suggested solutions are ideas. Then follows a sequence of mental testing of solutions as to their consequences, and modification of proposed solutions as a result of these tests until all known conditions are met. And so the process continues, the ideas and data are correlated, consequences noted, ideas modified, confirmed, or refuted, until at last a belief is reached which will resolve the perplexities.

For example of such a process, we may turn to one John Dewey himself describes:

You are on a ferry boat and you notice a pole protruding from the front end of the upper deck, midway across the beam of the boat. Your curiosity is aroused because it does not appear to have any useful purpose. You begin to reflect; for data you note that the pole contains no hawsers, such as would be used for mounting flags and that one of these poles is mounted at each end of the boat. You consider possible solutions: lightning rod? no, it is made of wood; ornament? no, it is by no means a thing of beauty; nor does it seem to have provisions for use as a hoist. A further fact not considered before is its position directly in front of the pilot house. This suggests the question, "Of what use is the pole to the pilot?" The possibility that the pole might be used to help the pilot steer the boat arises. A few tests follow, such as considering whether the pilot is in proper position to make use of the alignment of the pole, and finally the conclusion is reached that the pole is a steering guide.

I have chosen this simple example to point out how numerous are the opportunities for reflection, and how involved even simple cases may be. If you did not know the answer, do you think you would have easily arrived at it? If the opportunity should arise, test one of your friends. I tested one of mine. He didn't solve it. I daresay very few ferryboat riders have. Try to imagine how a machine could be constructed to do this simple bit of reflection!

The example has revealed that although the thought process was a progression toward a

settled condition of belief, nonetheless, there was much confusion of operations. Engineers might recognize a good deal of "feedback" in the process. However, it is valuable to recognize a progression of phases in reflective thinking. John Dewey recognized five phases of this activity. We have paraphrased his exposition of them below:

<u>Phase 1</u> - Recognition of a situation requiring some kind of action. Here the mind is exposed to sensations (data) and suggestions leap forward to possible solution. Key questions which foster reflection at this point are: What facts about this situation are missing? What is unfamiliar in this situation? What data is not related to what is already known about the situation?

<u>Phase 2</u> - Intellectualization of the difficulty into a problem. Perhaps several problems are involved. Useful questions are: Why is the situation unmeaningful? What changes to the situation or our comprehension of it would give it meaning?

<u>Phase 3</u> - Search for solution. Here, one suggestion after another is used as a leading idea or hypothesis to initiate and guide observation and collection of factual data. This is predominantly the creative phase. Thinking is sparked by a wide range of questions. The exact phrasing of the questions depends a great deal on the nature of the problem on hand, but those listed below will give an idea of their nature: How can two or more known facts be combined to effect the desired changes? Can we use more or less of something to improve the situation? What concept can be related to this problem that has not previously been considered? What old method can be applied to this new field?

Many questions of use in this phase can be found in Alex Osborn's book, "Your Creative Power". (12)

The keynote of this phase is the proposing of some action. Two attributes of mind are of primary importance at this stage: experience, and a strong flow of suggestions or ideas. Together these constitute what is commonly called imagination.

<u>Phase 4</u> - Evolving the tentative solution into a best solution. The leading ideas or hypotheses are tested, weighted, compared, and judged. Standards of judgment or criteria must be set up as a basis for decision. The possible consequences of the proposed solution must be considered. All these are aspects of the process of analysis which predominates at this point. The end result is one or more hypotheses which are the best apparent solutions to the problem upon which our future action will be based.

Questions which occur at this stage are: What are the consequences of putting this idea into use? What are the best bases for judging the two or more possibilities? What simple tests can we make to prove the point? What computations will resolve the issue?

One of the most emphatic points of Alex Osborn's book (12) is that the exercise of critical judgment, which is desirable in Phase 4, so often blocks useful imaginative thinking, which is essential to Phase 3. Society has encouraged Phase 4 or critical thinking, so that it often occurs before Phase 3 thinking has had sufficient scope. In fact, he organized "Brainstorming" sessions during which only questions characteristic of Phase 3 were permitted. This was done to prevent the occasional "crazy" idea which is really valuable from being lost. This comment is inserted here to emphasize the point that while the phase of judging is of obvious importance, it is useless until the creative phase has supplied ideas in the first place.

<u>Phase 5</u> - <u>Test by Action</u> - Here the best hypothesis is given the test of use. The action may be overt or imaginative, depending upon the subject matter. Conditions are deliberately arranged to see if results theoretically indicated will occur. To the extent that results bear out the hypothesis, confidence in its use is gained, and the doubtful situation has been replaced by a meaningful basis for action. This is another way of defining a concept.

What Gives Motion to the Thought Process

The thought process thus stands revealed as a set of operations upon mental images or ideas which arise from observation or suggestion. We might well ask: What keeps thinking in motion? Why should it progress from phase to phase? The role of the question becomes plain. The word "question" means literally a seeking. It is by this means that the mind searches for missing or needed ideas, as thinking progresses. The seeking is done in different phases. Hence, the questions change from phase to phase, which is another way of saying that the areas of search change.

It is important to emphasize the observation that the chief difference in the phases of the thought process described above is the difference in the character of the questions which are asked. Becoming conscious of this helps us improve our thinking efficiency. Essentially, these questions select the appropriate images and operations at the proper time. Conscious questioning can influence the thinking process, but much of this questioning is done habitually and hence subconsciously. Training can largely influence the individual's

habitual sequence of self-questioning, and indeed much of Dewey's work was directed to this end.

One other process is of importance to stimulate the flow of thought. This is inference. Drawing inferences may be looked on as the process of arriving at that which is absent from that which is at hand. The process involves testing that which is inferred for coherence with what is at hand. Inferences are important in the first phase of situation recognition, and in the fourth phase of critical judgment. In both these situations missing data must often be inferred to permit the thought process to continue.

In concluding our observations on the thought process, it might be noted that the phases exist for only as long as questioning in the given area is needed. They are of indefinite duration and importance; and some of the areas of search may be repeated in subsequent stages. Some element in a later phase may cause the process to be repeated through the whole five phases on a narrower scope. Whether this is done is generally considered a function of judgment in human beings. As we have already seen that judgment is the application of a specialized form of questioning, namely, that of comparing conclusions with criteria, it follows that this form of questioning must be present at least in a minor role in all phases of thinking.

Operations Involved in the Thought Process

We are now in a position to evaluate the question whether machines can be conceived to perform the operations of the thought process. Consider first the basic processes of questioning and inferring.

Questioning may be visualized as a methodical searching of specialized memory areas. The difference in the character of the questions appropriate to the several phases of the thought processes is mainly a difference in the area searched, or in the searching routine. We will go into this point further when we examine the operations involved in the separate phases of thought. It is this operation that is mainly responsible for keeping the entire thought process in motion, proceeding from step to step.

Inference involves a processing of the data accumulated up to a point to determine if some element is missing. First, the consequences of the data as it stands must be deduced. For example, using only this data a problem would be solved and an answer obtained. Then the answer is compared with similar previous solutions, and tested for consistency. The machine must then supply from memory tentative missing data and repeat the test until it concludes that the proposed new data is consistent. Thus inference is a combination of the more fundamental seeking operation with that of comparison.

In a similar manner, let us examine the five phases of the thought process and determine if each phase can be broken down into a series of operations which conceivably can be performed by a machine. If such is the case, we have established in a practical sense that reflective thinking can be done by machines. We shall try to describe these operations in such terms that a computer engineer will be able to imagine them being carried out by means reasonably familiar to him. Our belief in the ability of machines to think reflectively should correspond to the extent that these means seem realizable.

In Phase 1, situation recognition, the machine is immersed in a welter of sensations. We can design the machine so that some of these sensations can evoke automatic responses or suggestions. Many means of transforming physical sensations into digital codings are well known. We can imagine a scheme of specialized numbers which will acquire specialized meaning such as words have to human beings. The specialized numbers can of course be represented by electrical pulses.

The stream of coded sensations will be compared automatically with similar concepts already stored in the machine. The data itself will initiate the process. There must be present in the machine means capable of sorting the flow of meanings into classes so that the machine can bring forth from memory similar meanings. This comparative process makes possible the identification of data as unfamiliar. The identification "unfamiliar" gives the signal for the problem-solving process.

Consider as an example, the identification of the function of the pole on the ferryboat. In Phase 1 the question arises as to whether such a pole in such a place is worthy of further attention. Such a question could be simulated by a searching process which brings forth recordings (mental images) of similar situations from memory (or experience) for comparison with the presently sensed image. Comparison circuits can establish the similarity or differences. The judgment can then be formed that the function of the pole is not understood, and the process of reflective thought starts.

In Phase 2, formulation of a problem, the underlying question is "What changes can be made which will reduce the doubtful situation

to a meaningful one?" First, the causes of the doubtful situation must be sought: the question "Why?" must be answered. This implies an ability to recognize relationships among things; such as, if A depends on B, and B upon C, then A depends upon C. Our machine must recognize from the observations gathered in Phase 1 the possibility of some relationship. This it does by arranging some of the data and comparing the data with relationships it has standardized and stored in its experience. By this trial and error process the machine arrives at the inherent causal dependence of the new data among itself or it identifies it as dependent on a previously stored concept. When the basic relations are "understood", it becomes possible to identify what is rendering the data unmeaningful in some way. To do this, the machine must review the pattern of relationships in which it has arranged the data with reference to its previous knowledge of relations and identify the inconsistency. When the machine has done this, it has found the problem which must be solved.

In Phase 3, search for solution, the machine needs to search for possible ways to add meaning to the data, i.e., the tentative solutions to the problem. Finding the problem has narrowed the area which must be searched because the kind of change to the data is now known. For example, the tic-tac-toe machine knows that it must place an "X" in one of six remaining squares (a change) in accordance with certain rules. Its problem is thus defined. It can confine its search to its memory of all possible situations, find one like the present one, and so determine the proper move to make.

Many problems which confront human beings require more areas of search. For instance, if the problem were "How can this electric razor be improved?", the human being would try to solve the problem by searching among ideas stored in his memory having some relation. Such ideas might be: make it smaller; place shearing device on its side; make it lighter; increase the number of teeth in the shearing head; make the motor more powerful; change the kind of shearing action; use rotary cutting heads, etc.

Some of these ideas can be combined creating new ideas. For example, increasing the number of teeth in the shearing head could be combined with changing the shearing action; or changing the size or quantity of parts in the razor.

In like manner, a machine may perform these operations: it will search memory areas which are related to the problem for possible concepts which seem to be the desired change, and it will combine or vary them in size and quantity and judge if any of these appear also to be meaningful.

In Phase 4, critical reasoning, the machine needs to search for criteria so that quantitive comparisons can be made. In this stage the consequences of the tentative ideas must be weighed. The machine will often be able to do this numerically from the data at hand at this point. Circuits which perform logical, arithmetical, and comparing operations of the kind already incorporated in computers can do this work. However, in the "reflective thinking" computer the programming would be automatic. The machine could determine from the tentative, proposed solution the applicable series of operations capable of reaching a decision about it.

It would appear essential that at least primitive standards of reasoning and criticism be supplied to the machine. In other words, some basis of comparison must have been initially established for it. But with this elementary form of judgment and the natural development within the machine of the process of reflective thinking, other more refined standards of judgment would be evolved by the machine.

In Phase 5, action in regard to the best apparent solution is called for. All the action of the machine up to this point has been internal reflection; yet external action must usually be taken to establish the validity of the solution. Either the machine must act or it must communicate. It must present suggested courses of action and predicted consequences of them. But, and this is most important, the results of such action must be communicated back to the machine. Only then is the process of reflective thinking complete, since information about results is absolutely essential to build up reliable concepts in the machine.

Can Machines Be Designed to Perform the Operations of the Thought Process?

Before considering whether machines might be designed to perform the operations of the thought process, let us consider how present machines measure up. We have been able to describe all of the processes involved in the different phases of the process of reflective thought in terms of these basic operations:- questioning, comparisons, combining, rearranging, changing scale or quantity, logic, and arithmetic. All but the first type of operation has been incorporated in present-day computing machinery.

How basic the operation of questioning is to reflective thinking has been emphasized by the previous discussion. It would be valuable then to examine this process more closely. To do so we have chosen a specific question: "What is unfamiliar in this situation?" This question, it will be recalled, is characteristic of Phase 1, situation recognition.

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The process starts when data selected by the sensing device is grouped into a standardized set of data which will be called a situation element S. On proper orders which arise out of the data itself, a situation element S is stored in memory location M. S is then systematically subtracted from past situations stored in locations r thru r+n. (We assume here that S and the contents of location r -- abbreviated to C(r) -- can be expressed in terms of numbers in a meaningful way.). Then the situation in r thru r+n which differs least from S, call it T, can be distinguished by determining which subtraction gives the smallest difference. Knowledge of S and T and their difference is an answer to the question: we have determined both that the new situation differs from what was known, and also what situation it most closely resembles. Thus the area of unfamiliarity has been identified. The information S and T can now be transferred to new storage locations where new questioning routines may operate upon the information to eventually establish the meaning of the unfamiliar element.

The example brings out several interesting points. First, questioning arises automatically from the data. It does not need to be ordered by a tape. This is in contrast to the method of programming prevalent in modern computers. Questioning machines would not require any external orders. Second, questioning does not appear to require any operation that could not be performed by modern computing machines. Hence, we are in a position to answer the question posed at the beginning of the section. Yes, machines can be designed to perform reflective thinking.

No machines to our knowledge have been designed to perform the operations of Phase 1, situation recognition, and Phase 2, formulation of a problem. Such machines would require several questioning processes. Unquestionably, such machines would not be feasible for some time unless the field of data they would process would be very narrow. They would be the first problem-finding machines built, however.

Game-playing machines have been designed which in a limited sense are capable of the thinking of Phase 3, search for solution. In such machines the problem is well defined by the rules of the game and the machine seeks the best solution. The tic-tac-toe machine and the maze-solving mouse (11) are examples previously referred to. But much could be accomplished by machines capable of questioning operations, self-correction, and having large memory designed specifically to do Phase 3 operations.

Machines, of course, are designed to do operations of Phase 4, critical judgment. However, the addition of questioning circuits would greatly reduce the human programming effort. The machine would learn its programs.

In Phase 5, knowledge of results, only experimental learning machines have been constructed, or rather programmed, such as the experiment performed by A. G. Oettinger on the EDSAC (5). Here the machine received a signal indicating approval. Other methods of indicating satisfactory results to machines can be developed; this will greatly improve their ability to learn, and hence, to think.

Anticipated Gains & Losses from Creating Such Machines

Reflective thinking in human beings apparently has grown out of animal drives, chiefly the drives of self-preservation, hunger, and procreation. Somewhere in man's development, the ability to communicate meanings to other men came to pass. This marked a tremendous enhancement of memory to man, since now he could rely upon the collective memory of his culture. The doubts, the unsatisfactory situations, now could be recognized on a wider scale. Problem-solving evolved. Basically, reflective thinking in man has grown up in an emotional being as a tool in adapting himself to an unfriendly world. Animals such as birds, for example, have had no such development and lead purely instinctive and emotional lives.

This leads directly to the answer to the question as to whether machines can have human experience. William James was one of the first to point out how profound the effect the body has upon human experience. Thinking, feeling, consciousness, must all be in terms of our limbs, our eyes, our ears, ... The mind makes possible a framework of continuing life which many other creatures cannot experience. Machines which have memory can have continuous experience but hardly human experience because they lack the body properties of human beings.

Thus reflective thinking is not the primary purpose of man, but exists only to keep him living. Reflective thinking is a powerful instrument for him to use to pick his way through life, but that is all. On the other hand, the machines we would propose to create for the purpose of reflective thinking would have as their primary aim reflective thought. Reflection would be their business, their main function.

From such devices we should expect a degree of dependability unattained and perhaps unattainable in man. Consider our remarks concerning what brings man's thought process into being. Man may or may not recognize the need for changing a doubtful situation into a

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ROSTER OF ORGANIZATIONS IN THE FIELD OF COMPUTERS AND AUTOMATION

(Supplement, information as of Jan. 10, 1954)

The purpose of this Roster is to report organizations (all that are known to us) making or developing computing machinery, or systems, or data-handling equipment, or equipment for automatic control and materials handling. Each Roster entry when it becomes complete contains: name of the organization, its address, nature of its interest in the field, kinds of activity it engages in, main products in the field, approximate number of employees, year established, and a few comments and current news items. When we do not have complete information, we put down what we have.

We seek to make this Roster as useful and informative as possible, and plan to keep it up to date in each issue. We shall be grateful for any more information, or additions or corrections that any reader is able to send us.

Although we have tried to make the Roster complete and accurate, we assume no liability for any statements expressed or implied.

This listing is a supplement, and contains only revisions or additions as compared with the cumulative edition of the Roster published in the November issue of COMPUTERS AND AUTOMATION, vol. 2, no. 8, and the supplements published in the December issue, vol. 2, no. 9, and the January issue, vol. 3, no. 1.

Abbreviations

The key to the abbreviations follows:

Size
- Ls Large size, over 500 employees
- Ms Medium size, 50 to 500 employees
- Ss Small size, under 50 employees
  (No. in parentheses is approx. no. of employees)

When Established
- Le Long established organization (1922 or earlier)
- Me Organization established a "medium" time ago (1923 to 1941)
- Se Organization established a short time ago (1942 or later) (No. in parentheses is year of establishment)

Interests in Computers and Automation
- Dc Digital computing machinery
- Ac Analog computing machinery
- Ic Incidental interests in computing machinery
- Sc Servomechanisms
- Cc Automatic control machinery
- Mc Automatic materials handling machinery

Activities
- Ma Manufacturing activity
- Sa Selling activity
- Ra Research and development
- Ca Consulting
- Ga Government activity
- Pa Problem-solving
- Ba Buying activity
  (Used also in combinations, as in RMSa, "research, manufacturing and selling activity")

*C This organization has kindly furnished us with information expressly for the purposes of the Roster and therefore our report is likely to be more complete and accurate than otherwise might be the case. (C for Checking)

*A This organization has placed an advertisement in this issue of COMPUTERS AND AUTOMATION. For more information, see their advertisement. (A for Advertisement)

ROSTER

Audio Instrument Co., Inc., 133 West 14 St., New York 11, N. Y. / Oregon 5-7820 / *C, *A
Electronic, mechanical, and optical analog computers. Precision electronic instruments. Time-delay units. Fire control equipment, logarithmic amplifiers. Specialized passive computer which corrects for film nonlinearity in photometric work, etc. Ss(10) Se (1949) DACSc RCSa

Automatic Electric Co., 1033 West Van Buren St., Chicago, Ill. / Haymarket 1-4300 / *C, *A
Automatic electrical systems, telephone equipment, relays, stepping switches, etc., for computing machinery companies and independent telephone companies. Automatic control components. Ls(6000) Le(1892) ICc RMSa

Computer Control Co., 106 Concord Ave., Belmont, Mass. / Belmont 5-6161 / and 1429 Promenade Hwy., Santa Monica, Cal. / *C
Computers and computer components, digital data-handling systems, solid delay line acoustic memory, computer test equipment, dual beam conversion kits, specialized systems and instrumentation. Operating and servicing Raydac at Pt. Mugu. Ss(22) Se(1952) Dc RMSa

Eckert-Mauchly Division, Remington Rand, Inc., 3747 Ridge Ave., Philadelphia, Pa., and elsewhere *C, *A
All purpose electronic digital computers. Univac Factronic System. Ls(600)? Se(1946) Dc RCMSa SEE also Remington Rand, Inc.

Engineering Research Associates, Div. of Remington Rand, Inc., 1907 West Minnehaha Ave., St. Paul, Minn., and 510 18th St. South, Arlington, Va. *C, *A
Digital computers; ERA 1101 and 1103 electronic digital computers; the Logistics Computer. Magnetic storage systems, including magnetic heads, magnetic drums, etc. Shaft-position indicator systems, self-recording accelerometers, analog magnetic recording systems,

data-handling equipment, special purpose communications equipment, pulse transformers. Ls(750) Se(1946) DC RMCPSa SEE also Remington Rand, Inc.

Hughes Research and Development Laboratories, Hughes Aircraft Co., Culver City, Calif. *A
Automatic data-handling systems. Industrial process control systems. Small, powerful, automatic electronic digital computer for airborne use. Fire control equipment. Aircraft control. Navigation systems. Ls Me DAc RMSa

Intelligent Machines Research Corp., 134 So. Wayne St., Arlington, Va. / Jackson 5-7226 / *C, *A
Devices for reading characters on paper, etc. Pattern interpretation equipment. Sensing mechanisms. Digital computer elements. Ss(10) Se(1951) Dc RCMSa

Laboratory for Electronics, 51 Pitts St., Boston 14, Mass. / Richmond 2-3200 / *C, *A
Analog and digital computers, special computers to suit customer requirements, delay lines (mercury, quartz), plug-in packages for computer applications, etc. Ls(700) Se(1946) DAc RMSa

Monrobot Corp., Morris Plains, N. J. / Morristown 4-7200 / *C, *A
Monrobot automatic electronic digital computers. Subsidiary of Monroe Calculating Machine Co. Ss(32) Se(1952) Dc RMSa

Raytheon Manufacturing Co., Waltham, Mass. / Waltham 5-5860 / *C *A
Electronic digital computer systems for scientific applications (RAYDAC), and for general accounting and data-handling applications. Tape-handling mechanisms, magnetic heads, magnetic shift registers, and other computer components and sub-systems. Computing service to analyze problems in applied mathematics, in engineering, and in industrial logistics by digital computer. Radar, fire control, microwave equipment, etc. Ls(20,000) Me(1925) DAc RMSa

Remington Rand, Inc., 315 4th Ave., New York 10, N. Y. / Spring 7-8000 / *C
Punched card machines, office machines, electronic digital computing systems (Univac Factronic System, ERA 1101, ERA 1103), servomechanisms. Ls(30,000; 1800 on computers) Le DASc RCMSa SEE also Eckert-Mauchly Division and Engineering Research Associates Division.

Soroban Engineering, Inc., Box 117, Melbourne, Fla.
Electronic digital computers and accessories. Automatic keyboard device with 21 keys for input to an automatic electronic digital computer. Ss Se(1953) Dc RMSa

Zeuthen and Aagaard, Ltd., 6 Toldbodvej, Copenhagen, Denmark
Portable adding machine (Contex); dictating machine (Rex Recorder) with magnetic recording on plastic disc using impregnated magnetic particles and permitting 10,000 reuses; other office machines. ?s Le Ic RMSa

ROSTER OF ORGANIZATIONS MAKING COMPONENTS
(Information as of Jan. 10, 1954)

The purpose of this roster is to report organizations making components (but not making complete systems) that enter into computing machinery or data-handling equipment or equipment for automatic control and materials handling. Since this would be a very large list if we included all organizations making motors, resistors, magnetic cores, condensers, etc., this roster is not a free listing. For the conditions of listing, see page 31; also the listing is subject to editing for completeness and objectivity; for the abbreviations see the "Roster of Organizations in the Field of Automatic Computers and Automation".

ROSTER

Alden Electronic and Impulse Recording Equipment Co., Alden Research Center, Westboro, Mass. *A
Facsimile recording equipment and facsimile components. Ma SEE Alden Products Co.

Alden Products Co., 117 North Main St., Brockton, Mass. / Brockton 160 / *A
General and specific components for digital and analog computing machinery; plug-in components, sensing and indicating components, magnetic delay line units, magnetic storage cores, etc. Ms(300) Me(1930) Ic RMSa

Alfax Paper and Engineering Co., Alden Research Center, Westboro, Mass. *A
Electrosensitive recording papers. Ma SEE Alden Products Co.

Ferroxcube Corporation of America, 377 East Bridge St., Saugerties, N. Y. / Saugerties 1000 / *A
Ferrite core materials, including pot cores, cup cores, recording heads, and microminiature toroids with square hysteresis loop. Magnadur permanent magnet materials. Ms(100) Se Ic RMSa

Sprague Electric Co., 377 Marshall St., North Adams, Mass. *A
Capacitors: miniature, and low dielectric hysteresis loss, for computer applications. Standard capacitors; precision and power type resistors; pulse transformers; radio interference filters. Ls ?e Ic RMSa

I. By Alston S. Householder,
Oak Ridge National Laboratory,
Oak Ridge, Tenn.

I would like to make a few comments on the glossary published in "Computers and Automation". (Section A,B, published in vol. 2, no. 2, March, 1953; Section C to E, vol. 2, no. 4, May, 1953; Section F to Z, vol. 2, no. 9, December, 1953; reprinted together. -- Edit.). I want to say at the outset that I think you are doing a good job and an important job. In fact, it is because I approve on the whole, and hope very much that you will make the glossary a permanent feature, adding and revising from time to time, that I want to make some rather detailed suggestions and criticisms.

Reporting vs. Legislating

First, you say that you are reporting and not legislating. Nevertheless, when a definition appears on a printed page, it becomes in some degree standardized; people will refer to it and tend to use the word in just that way. Moreover, one's reporting is at best partial, subject to the limitations of one's own experience, judgment, and understanding. Therefore, the lexicographer has a responsibility which he may disclaim but cannot in fact escape. I urge you, therefore, to think seriously, as you formulate your definitions, not only of how you think the terms are used, but also of how they might best be used.

In deciding how a term might best be used there are several factors to consider. Obviously one is that the definition you propose should conform in some sense with general usage as you have observed it. In claiming to report rather than to legislate you are indicating that this is your sole criterion. But another factor to be considered is that the term should conform with nontechnical usage so far as possible (see my comments below on "routine"). Again, if two or more terms seem to be used interchangeably but somewhat ambiguously, you might well consider whether clarity could be served by introducing a distinction. If you decide that there is no distinction to be made, you are well within your rights to recommend the use of one of the terms in preference to the other.

I agree with your point in replying to C. L. Perry (see "Computers and Automation", vol. 2, no. 4, May, 1953, pp 21-22 -- Edit.) that waiting for committee reports would take too long. Also questionnaires would take too long and be too expensive. Actually the great majority of terms will cause no trouble. Anyone reasonably familiar with the field, and willing to take the trouble, could sit down and write out a definition of any one of these and there would be no argument. The rub will occur with only a small minority of the terms.

I can appreciate your desire to be impartial and merely report, and your objection to authoritarianism. But (let's face it!) most of the definitions you publish will be accepted by default. Your glossary, by virtue of its existence and publication, is a standard of reference, and will remain so at least until another one appears. I do not think this is necessarily bad. On the contrary, I am arguing that it will be still better if you accept the fact and proceed to legislate -- naturally after a critical consideration of each bill!

Then, if someone objects in particular instances, let him write you, as I am doing. After all, you have invited criticism. You can periodically publish the objections, or the proposed alternatives, and invite further comment. Eventually, in the light of whatever comments you have received, you, yourself, should make a decision. If people refuse to use a term as you recommend, so be it! You will hardly remain ignorant of the fact, and you can take cognizance of it whenever you see fit.

I think that I am not really authoritarian at heart, even though I may sound so here. But, as I have said elsewhere, language exists for purposes of communication, and in scientific discourse one wishes to communicate ideas, clearly and unambiguously. For this purpose clear and unambiguous usage is essential. I believe the policy I propose will contribute most to the attainment of this objective.

In a cooperative spirit I would like now to comment on a few of your definitions.

"Routine"

In the dictionary the word "routine" is defined as a "course of procedure", and "procedure" is "conduct" or a "mode of action". I therefore suggest that this word be reserved to designate what the machine actually does. What one writes is a program for a routine or

a subroutine. In this connection I see no reason why a term "subprogram" should not be introduced and recommended, as a means of avoiding some circumlocution.

"Readaround"

Without risk of ambiguity one can use the term "readaround" as a noun to denote what is, in fact, not a ratio at all. I therefore suggest that you eplace the entry "read-around-ratio" by the entry:

> "readaround (sometimes incorrectly called "read-around-ratio") -- ..."

where the dots denote, of course, the definition. I would like, also, to suggest a rephrasing of the definition: "in cathode-ray-tube storage, the number of times a memory cell can be regenerated without disturbing the state of neighboring cells".

"Cell"

This leads to a few terms we are using at Oak Ridge and which I wish to propose. We use the term "cell", instead of "memory register", reserving "register" for all others. We say that a cell, and also a register, contains n elements (all binary in the Oracle). We say that a binary element is in one of two possible states and a cell or register is in one of 2^n possible states; that any state of a cell or register is a particular word; that the state represents the word and the word designates the state.

"Information"

This leads to "information", which you define as a particular "set of marks" or "arrangement". Claude Shannon does not seem to give an explicit definition of "information", but it is conveniently distinguished from and related to "message" and "meaning". Of the possible states of a system, some may be taken to have a meaning, in which case each of these states represents a message. The number of messages, or any monotonic function of this number, can be taken as a measure of the amount of information conveyed by any one message, provided all messages are equally probable (in computing systems I believe this can be assumed). What meanings are attached to the messages are entirely irrelevant. Actually Shannon uses the logarithm to the base 2. When this measure is used, the unit is called a "bit". It may be true, as you say, that "bit" is used colloquially for "binary digit" (at Los Alamos they say "bigit"), but if so it is by an extension of the meaning proposed by John Tukey and endorsed by Shannon. In binary machines, generally every state of a cell or register is meaningful; hence with n elements in a register there are 2^n possible messages. Hence using Shannon's measure, the amount of information is equal to the number of binary digits, which could account for the colloquial use of the word "bit". Nevertheless, it seems to me that the Los Alamos term "bigit" should be encouraged, since in a decimal machine a decimal digit requires 4 bigits, but the information is only $\log_2 10$ bits.

"Infinity"

Do people really use "infinity" as you say? I see no possible advantage in it.

"Rounding, Truncating"

I suggest that "rounding" and "truncating" be distinguished as applied to reducing precision: in the case of pi = 3.14159265 ... , 3.1416 illustrates the former and 3.1415 illustrates the latter. In this connection there are other terms that become important in discussing the use of computers, though they are not directly applicable to the computers themselves. Arthur Sard objects to the expression "round-off error", and although I have used it in my book (being printed by McGraw Hill Book Co., not yet out -- Edit.) I agree with him and regret that I used it. One should say "errors due to rounding", though I believe "rounding error" is acceptable and certainly to be preferred over "round-off error". In my book I have used the following terms which I believe are worthwhile: "initial errors", "generated errors", "propagated errors" and "residual errors". If x is the true value of the argument, and x^* the quantity used in computation, then, assuming one wishes $f(x)$, $x - x^*$ is the initial error; $f(x) - f(x^*)$ the propagated error. If f_a is the Taylor, or other, approximation utilized, then $f(x^*) - f_a(x^*)$ is the residual error. If f^* is the actual result then $f_a - f^*$ is the generated error, and this is what builds up as a result of rounding.

"Regenerating"

Getting back to the computers themselves, I suggest that instead of "regenerating" you define

> "regenerate -- in electrostatic storage, to restore information currently held in a cell, in order to counteract the effects of fading and of disturbances coming from neighboring cells."

I suggest also introduction of a term such

as "evanescent" to describe memories which fade. Is electrostatic storage necessarily the only evanescent kind?

II. By E. C. Berkeley, Editor of "Computers and "Automation"

We do plan that additions and revisions of the glossary will be a permanent feature of "Computers and Automation". But to make a real success of this endeavor, we need the help of many people.

For example, any one who is interested in nomenclature, -- and we can think right off of E. G. Andrews, G. M. Hopper, John W. Carr III, S. B. Williams, C. V. L. Smith -- whenever he notices a new expression being used, or whenever he notices that an expression that he may have coined is coming into use in his vicinity, might send us a note, mentioning the expression and telling the meaning which he gives to it. We could publish it in the glossary -- not as a "legislated" new term, but as a report of a new term that has gone into use: "here is an expression which has begun to be used -- and this is the meaning which it presently has".

In addition, there are some committees on nomenclature. One for example is an IRE committee whose chairman is Mr. A. G. Jensen, of Bell Telephone Laboratories, Murray Hill, N.J. But unfortunately most committees are clannish; they feel that they should not report their work until it is complete, and that it should then be reported first in the proceedings of the society which has sponsored that committee. Although we would of course be very glad to report their discussions of terms as and when occurring, it seems doubtful that any committee members will feel free to tell us. In the assignment of making decisions about many small controversial subjects, a large committee with members from all over the country is not likely to be quick.

A third method for obtaining information about new terms and expressions would be for "Computers and Automation" to make arrangements for correspondents at various computing centers. We should be very glad to make such arrangements. If any of our readers who is associated with a center of development or application of computing machinery or automation would like to be a correspondent, he is cordially invited to write to us.

In regard to the question of reporting vs. legislating which Alston Householder discusses so well, it seems to us that there is a compromise possible. Suppose we have two terms, "program" and "routine", where it does seem advantageous to encourage them to differentiate. Next to the entry in the glossary, we could put a comment such as "this meaning appears preferable." In fact, part of the reporting of the meaning of a term, might very well include reporting what seems to be a good direction for its meaning to develop into.

Alston Householder is completely right, we think, when he says "language exists for purposes of communication, and in scientific discourse, one wishes to communicate ideas, clearly and unambiguously". All of us in the field of computers and automation are basically engineers in the automatic handling of information. Surely we should be keenly aware of the handling of information by human beings, and do our best to apply good engineering to principles and practices in that area too.

*——————— * ———————*

FORUM

1. Detroit Conference on Training Personnel for Computers. Received January 4, from Arvid W. Jacobson and Elbert P. Little, Computation Laboratory, Wayne Univ., Detroit 1, Mich.:

The purpose of this circular is to solicit your cooperation in holding a joint conference of groups concerned with the training of personnel for automatic computers ... We propose that a conference be held at Wayne University on ... Tuesday and Wednesday, June 22 and 23. ... It is hoped that a number of organizations in addition to Wayne University will sponsor the conference: National Science Foundation, Association for Computing Machinery, IRE Professional Group on Electronic Computers, Association for Engineering Education, and others ... Proposed topics for discussion are: manpower requirements in the computer and allied fields; a suitable curriculum in machine computation; increasing the number of high school graduates with training in mathematics and science; the effect of high speed computers on the training of applied mathematicians, engineers, physicists, and social scientists; ways to achieve cooperation between industry, government, and educational institutions in computer training ... We will appreciate your prompt replies and suggestions.

* * *

2. Institute of Management Sciences. Received January 12, from Merrill M. Flood, Columbia University, New York:

(continued on page 28)

settled one. Within its scope, the machine will always recognize this need and from its data will always attempt to find problems which need to be solved.

In man, the underlying emotional character of his being influences his thinking process in many distracting ways. His ability to recall from his memory is greatly influenced by emotional associations. Some ideas, names, or facts, are impossible for him to consciously recall because of some undesirable association. Other ideas are unduly emphasized. When these emotional blocks occur at strategic points in the thinking process, man's thinking will dictate biased action. Of course, emotions lend richness to man's life and variety to the individual's personality, but they do interfere with precision in the reflective thought process.

We can welcome the creation of thinking machines as means of performing thinking in two important ways now hampered in human beings by their emotional heritage; namely, the machines will think more dependably and more precisely.

But in addition, to meet the many problems of the modern world (such as the inexorable pressure of population increase), man is forced to seek every ally and use every instrument. To reduce the labor of mathematical analysis, he has built high-speed digital computing machines. But this leads to drudgery in preparing programs to direct the solution of such problems. Ways must be found to make machines to learn how to program much of their own work, and this is already contemplated. But even this will be found not enough. Machines will have to help man by finding the problems for us in their own special fields and searching for solutions. When such machines are devised, it will probably be just in the nick of time to help man grope with the enormous bulk of problems besetting him.

Summary

Throughout this article, we have standardized our meaning of thinking as reflection in John Dewey's sense. Reflective thinking has been shown to be a series of operations on tentative ideas or suggestions. Machines incorporating memory and a procedure for standardizing meaning, thus forming concepts, are equipped with the raw capacities with which to perform reflective thinking.

The process of reflective thinking proceeds from stage to stage by means of a seeking operation called questioning. The five phases of the process require questioning of different character. The phases (situation recognition, problem finding, search for solutions, determining best solution, and test by action) can be resolved into operations. These operations have here been defined only to the extent sufficient to show that they can be performed by electronic or mechanical devices of contemporary design.

Thinking appears to be the endless repetition of a few intrinsically simple spontaneous operations.

Computing machines which have been built have been largely limited by design to the analytical type of thinking involved in Phase 4. Some game-playing machines can do Phase 3 thinking. None have been designed to find problems (Phase 2) or automatically recognize need for new meaning (Phase 1). The number of operations involved in such thinking could be quite large.

An operation basic to reflective thought which has not up till now been given much attention is the questioning process. This process permits spontaneous movement of thought from phase to phase without recourse to external commands.

Only few controls would be available to human operators of such machines. Some interesting controls would be to restrict the kind of data input, or to vary the machine's standards of comparisons.

Machines for reflective thinking will be built to help man solve problems which tend to increase at an accelerating rate as his numbers increase. They will not supplant him, but will be vitally needed tools. They will be superior to man in that their thinking will be more dependable and precise.

As Rufolph Flesch (1) points out, a person believes that a machine can think largely on the basis of his background and emotional makeup. However, if we can accept the validity of John Dewey's conception of the thought process, I believe that we are forced to the conclusion that machines can do reflective thinking. In all probability, it will become vitally necessary for them to do so.

Future Work

Use of John Dewey's concept of thinking leads to promising paths to explore. It would seem to point a way to extend vastly the usefulness of computing machines. It suggests the building of machines capable of performing the questioning process and the deliberate design of machines, first to do Phase 3 (search for solutions), then Phase 2 (finding problems), and then all phases of reflection. Ways to

(continued on page 28)

ROSTER OF ORGANIZATIONS MAKING COMPONENTS -- CONDITIONS FOR LISTING

Any organization making components that can be used in computing machinery or data-handling equipment or equipment for automatic control or material handling may be listed in the "Roster of Organizations Making Components". The cost for the listing is $3.50 a line with a minimum of four lines (a "line" consists of 80 characters including spaces); if a company making components advertises in the same issue, it will receive a four-line listing free. The listing will be subject to the customary editing for completeness and objectivity.

If you are interested in a listing for your organization, please supply the information for a Roster entry (see p. 21) and write to Edmund C. Berkeley and Associates, Publishers of COMPUTERS AND AUTOMATION, 36 West 11 St., New York 11, N. Y.

overcome the limitations of machines for this work need to be found. How can they be best specialized for Phase 1 (situation recognition)? What sort of control of the machine would be best? Should judgment be controlled — or once designed, should it operate freely? Would such a machine become biased? Will construction of such machines add further insight into human thought? Will such machines be errorless? Will they give us insight into what causes errors in humans? Will they develop emotions?

Acknowledgment

I wish to acknowledge the valuable assistance and suggestions of Mr. Jack Cubert and Mr. Eugene F. Grant of The W. L. Maxson Corporation.

References

1. R. Flesch, "How To Talk About Computers", Computers and Automation, Vol. 2, No.5, July 1953

2. J. A. Winter, M. D., "Thinking in Men and Machines", Astounding Science Fiction, August 1953

3. E. C. Berkeley, "Giant Brains", John Wiley & Sons, N. Y., 1949

4. Reference 3, Page 5

5. M. V. Wilkes, "Can Machines Think?", Proc. of the I.R.E., Vol. 41, No. 10, Oct.1953, pp 1230-1234

6. John Dewey, "How We Think", D. C. Heath & Co., Boston, 1915

7. J. Nathanson, "John Dewey", Scribners, N. Y., 1951 (A short, easily comprehended introduction to Dewey's philosophical approach. This background may assist the reader who has not had an opportunity to become familiar with Dewey's work to follow our presentation.)

8. C. P. Curtis, Jr., and F. Greenslet, "The Practical Cogitator", Houghton-Mifflin Co., N. Y., 1945, p 17. (The quotation is from "Novum Organum" by Francis Bacon dated 1620.)

9. G. M. Hopper and J. W. Mauchly, "Influence of Program-Techniques on the Design of Computers", Proc. of the I.R.E., Vol.41, No. 10, Oct. 1953, pp 1250-1254

10. J. Huxley, "Man Stands Alone", Harper & Brothers, 1941. (The essay on "The Intelligence of Birds")

11. C. E. Shannon, "Computers and Automata", Proc. of the I.R.E., Vol. 41, No. 10, Oct. 1953, pp 1234-1241

12. A. Osborn, "Your Creative Power", Scribners, 1950.

FORUM

(continued from page 24)

Wm. W. Cooper, Assoc. Prof. of Industrial Management, Carnegie Inst. of Technology, has been elected the first president of the new Institute of Management Sciences. George Kozmetsky, Hughes Aircraft Co., was elected secretary-treasurer. The Council includes: Merrill M. Flood, Prof. of Industrial Engineering, Columbia Univ; Cuthbert Hurd, IBM ; Herbert A. Simon, Prof. of Industrial Management, Carnegie Inst. of Techn.; Melvin E. Salveson, Director of Industrial Logistics Research Project, Univ. of California at Los Angeles; Leo H. Query, Eastman Kodak Co.; Alexander Orden, Burroughs Research Laboratory.

The object of the new institute is to disseminate information on technological advances as they pertain to the business world in general, and specifically on the management level. This is important because of rapid, continuing developments in new areas of managerial controls, especially in the field of electronics. ... The institute plans to publish a quarterly journal called "Management Science", and issue a regular bulletin of news and activities for members. ... Temporary headquarters for the Institute will be at the Carnegie Inst. of Techn., Pittsburgh. Pa.

* * *

3. <u>One-Day Meeting, on "The Application of the Automatic Factory to the Production of Electronic Equipment".</u> Received January 12, from the New York Section of the Inst. of Radio Engineers (condensed):

Saturday, Jan. 23, at the Engineering Societies Bldg., 33 West 39 St.: Solderless Wrapped Connections, by R. F. Malline, Bell Telephone Laboratories / Automatic Production Techniques for Miniaturized Electronic Equipment, by F. M. Hom, Stanford Research Inst. / Development of Systems of Mechanized Assembly, by W. H. Hannahs, Sylvania Electric Products; Project Tinkertoy, by R. L. Henry, National Bureau of Standards / "One More Step", by W. Hausz, General Electric Co. / Chairman, John Diebold.

*

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Year of entering the computing machinery field?..........

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READER'S INQUIRY FORM

Please send me additional information on the following subjects for which I have circled the CA number:

1	2	3	4	5	26	27	28	29	30	51	52	53	54	55	76	77	78	79	80	101	102	103	104	105	126	127	128	129	130
6	7	8	9	10	31	32	33	34	35	56	57	58	59	60	81	82	83	84	85	106	107	108	109	110	131	132	133	134	135
11	12	13	14	15	36	37	38	39	40	61	62	63	64	65	86	87	88	89	90	111	112	113	114	115	136	137	138	139	140
16	17	18	19	20	41	42	43	44	45	66	67	68	69	70	91	92	93	94	95	116	117	118	119	120	141	142	143	144	145
21	22	23	24	25	46	47	48	49	50	71	72	73	74	75	96	97	98	99	100	121	122	123	124	125	146	147	148	149	150

PATENTS

by Hans Schroeder, Milwaukee, Wisconsin

The following is a compilation of patents pertaining to computers and associated equipment from the Official Gazette of the United States Patent Office, dates of issue as indicated. Each entry consists of: patent number / inventor(s) / assignee / invention.

November 17, 1953: No applicable patents

November 24, 1953: 2,660,370 / G F Daly and F V Adams, Endicott, N Y / IBM, N Y / Electro-mechanical number storage device

2,660,371 / D J Campbell, Richmond Hill, S P McCabe, Jr, Freeport, H Harris, Jr, Cedarhurst, N Y / Sperry Corp / Comprehensive gun positioning calculator

2,660,372 / B M J Leclerc, Fontenay Sous Bois, France / Compagnie des Machines Bull, Paris, France / Device for electrically comparing record cards

2,660,669 / C F West, Stoughton, Mass, / Raytheon Mfg Co, Newton, Mass / Cathode-ray type information storage tube

2,660,700 / W O Gates, Beverly, Mass / United Shoe Machinery Corp, Flemington, N J / Apparatus for controlling production machines electrically

December 1, 1953: 2,661,152 / P Elias, Cambridge, Mass / - / Electronic analog multiplier

2,661,153 / A W Vance, Cranbury, N J / RCA / Electronic multiplier

2,661,442 / J A Buckbee, Wellesley, Mass /Raytheon Mfg. Co, Newton, Mass / Cathode-ray type information storage tube

December 8, 1953: 2,661,897 / G Herzog and B D Lee, Houston, Texas / Texas Co, N Y / Electrical analogue of mineral strata being drilled

2,661,898 / F W Bubb, Webster Groves, Mo / Phillips Petroleum Co / Electrical analogue simulating a segment of a pumping unit

2,661,902 / H S Wolff, Oxford, and M G Story and D J Behrens, Strand, London, Eng / National Research and Development Corp, London, England / Apparatus for counting microscopic bodies in a state of random distribution

2,662,144 / J J Wilentchik, New York, N Y / - / Functionally adjustable voltage division device

2,662,213 / P B Vanderlyn, Ealing, London, Eng / Electric and Musical Industries, Ltd, Hayes, Eng / Electronic means for indicating the logarithmic value of a magnitude

COMPUTERS AND AUTOMATION -- BACK COPIES & REPRINTS

ARTICLES: October, 1952: Communication and Control in the Computing Machinery Field
The Parameters of Business Problems — Edmund C. Berkeley
January, 1953: Brains: Electronic and Otherwise -- A. S. Householder
What Computers Do — S. B. Williams
The Parameters of a Business Problem in Reading — C. H. Dent
Automatic Computers on Election Night -- E. F. Murphy and E. C. Berkeley
March: Gypsy, Model VI, Claude Shannon, Nimwit, and the Mouse — George A. W. Boehm, Science Editor, Newsweek
Water and Computers -- Henry M. Paynter, Jr., Mass. Inst. of Technology, and Neil Macdonald
The Concept of Automation — E. C. Berkeley
The ERA 1103 Automatic Computer -- Neil Macdonald
April: The Art of Solving Secret Ciphers, and the Digital Computer -- Fletcher Pratt
Avenues for Future Development in Computing Machinery -- Edmund C. Berkeley
Hungarian Prelude to Automation --Gene J. Hegedus
May: Compiling Routines — Grace M. Hopper, Remington Rand
Mechanical Translation -- Andrew D. Booth, Birkbeck College, London
Medical Diagnosis -- Marshall Stone, University of Chicago
July: Machine Translation — Y. Bar-Hillel, Mass. Inst. of Technology
Robot Traffic Policemen — George A. W. Boehm, Science Editor, Newsweek
How to Talk About Computers — Rudolf Flesch, Author of "Art of Plain Talk"
September: The Soviet Union: Automatic Digital Computer Research -- Tommaso Fortuna
Digital Computer Questionnaire -- Lawrence Wainwright
"How to Talk About Computers": Discussion — G. G. Hawley and others
October: Computers in the Factory -- David W. Brown
The Flood of Automatic Computers --Neil Macdonald
The Meeting of the Association for Computing Machinery in Cambridge, Mass., September, 1953 — E. C. Berkeley
November: Who Will Man the New Digital Computers? -- John W. Carr III
Electronic Equipment Applied to Periodic Billing -- E. F. Cooley
Air-Floating: A New Principle in Magnetic Recording of Information — Glenn E. Hagen
December: How a Central Computing Laboratory Can Help Industry -- Richard F. Clippinger
"Combined" Operations in a Life Insurance Company Instead of "Fractured" Operations — R. T. Wiseman
"Can Machines Think?": Discussion — J.L. Rogers and A. S. Householder
January, 1954: The End of an Epoch: The Joint Computer Conference, Washington, D. C., December, 1953 — Alston S. Householder
Savings and Mortgage Division, American Bankers Association: Report of the Committee on Electronics, September, 1953 -- Joseph E. Perry and others
Automation in the Kitchen -- Fletcher Pratt

REFERENCE INFORMATION:

Roster of Organizations in the Field of Computers and Automation / Roster of Automatic Computing Services / Roster of Organizations Making Components / List of Automatic Computers / Who's Who in the Field of Computers and Automation / Books and Other Publications/ Glossary / Patents

Price of back copies, if available, $1.25 each.

A subscription (see rates on page 4) may be specified to begin with any issue from November, 1953, to date.

REPRINTS: Index No. 1 (from December issue) -- 20 cents
Glossary of Terms in the Field of Computers and Automation (from three 1953 issues) — 60 cents

WRITE TO:

Edmund C. Berkeley and Associates
Publishers of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N.Y.

ADVERTISING IN "COMPUTERS AND AUTOMATION"

Memorandum from Edmund C. Berkeley and Associates
Publishers of COMPUTERS AND AUTOMATION
36 West 11 St., New York 11, N. Y.

1. What is "COMPUTERS AND AUTOMATION"? It is a magazine published monthly, except June and August, containing articles and reference information related to computing machinery, robots, automatic controllers, cybernetics, automation, etc. One important piece of reference information published is the "Roster of Organizations in the Field of Computers and Automation". The basic subscription rate is $4.50 a year in the United States. Single copies are $1.25. The magazine was called THE COMPUTING MACHINERY FIELD until the March, 1953, issue; prior to that issue, it was published less often than ten times a year.

2. Who are the logical readers? The logical readers of COMPUTERS AND AUTOMATION are some 4000 persons who are concerned with the field of computers and automation. Many people are entering this field all the time. These include a great number of people who will make recommendations to their organizations about purchasing computing machinery, similar machinery, and components, and whose decisions may involve very substantial figures. We have been carefully gathering the names and addresses of these people for some time and believe we can reach them. The print order for the February issue was 1600 copies. The paid subscriptions on December 10, 1953 were a little over 1000. The overrun is largely held for eventual sale as back copies.

3. What type of advertising does COMPUTERS AND AUTOMATION take? The purpose of the magazine is to be factual and to the point. For this purpose the kind of advertising wanted is the kind that answers questions factually. We recommend for the audience that we reach, that advertising be factual, useful, interesting, understandable, and new from issue to issue. We have had a number of comments expressing satisfaction with our style of advertising.

4. What are the specifications and cost of advertising? COMPUTERS AND AUTOMATION is published on pages 8½" by 11" and produced by photooffset. The closing date for any issue is approximately the 10th of the month preceding. If possible, the company advertising should produce final copy, which should be actual size and assembled, and may include typing, writing, line drawings, printing, screened halftones, etc. — any copy that may be photoffset without further preparation. If inconvenient to produce this, we will take rough copy and arrange with the printer to prepare it; there will be small additional charges in this event. Display advertising will be sold in units of full pages (ad size 7" by 10", basic rate $130), and half pages (basic rate $70); back cover, $250; inside front and back cover, $160. Classified advertising will be sold by the word (40 cents a word), with a minimum of ten words. The following discounts will apply to display advertising excluding cover space: 20% for a company with less than 50 employees and a publisher of books; 40% for a company of less than 20 employees.

5. Who are our advertisers? Our advertisers in recent issues have included the following companies, among others:

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Midget with the giant brain

The Problem

To design and build a computer for airborne automatic control systems—with severe restrictions imposed on size, weight and operation under extreme environmental conditions; in short, a computer that would be small, simple, reliable, rugged—and easy to build and maintain.

At Hughes Research and Development Laboratories this problem was examined exhaustively, and it was concluded that a digital computer offered the best means for satisfying the requirements because of its ability to solve complex problems accurately and quickly.

Because the requirements of this application could not be met by existing digital computers, owing to their large size, the following developments were undertaken:

1. Simplification of the logical structure of the computer through the use of a mathematical theory of computer design based on Boolean algebra—but with retention of the operational versatility of a general-purpose computer.

2. Development of ingenious circuitry to utilize the new logical designs.

3. Achievement of minimum size by the use of subminiature techniques, including germanium diodes, subminiature tubes, and etched circuits.

4. Employment of unitized construction: plug-in units of flip-flop circuits and diode networks.

Need for subminiaturization, then, was a governing factor. Consequently, entire new techniques for making things not only vastly smaller, but at the same time easier to build and service, were developed by Hughes. This is a continuing process and there is indication of even more significant advancement in miniaturization for the future.

A major effort at Hughes is also devoted to adapting electronic digital computer techniques to business data processing and related applications—destined for far-reaching peacetime uses.

One of the subminiature switching circuits from the Hughes airborne electronic digital computer is examined by Dr. Eugene M. Grabbe (right), Associate Head, Computer Systems Department, Advanced Electronics Laboratory, and Phil A. Adamson of the Technical Staff, Radar Laboratory.

Visit the Hughes Exhibit at the
WESTERN COMPUTER CONFERENCE AND EXHIBIT
Los Angeles, February 11, 12
Ambassador Hotel

ENGINEERS AND PHYSICISTS

Activities at Hughes in the computer field are creating some new positions in the Computer Systems Department. Experience in the design and application of electronic digital computers is desirable, but not essential. Engineers and physicists with backgrounds of component development or system engineering are invited to apply.

ADDRESS: *Scientific and Engineering Staff*

Hughes
RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

ADVERTISING INDEX -- FEBRUARY, 1954

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Every advertisement in this issue, we believe, is factual and objective. For these reasons, we think that the advertising is likely to be worth reading. So far as we can tell, the statements made are reasonable, informative and worth considering.

Following is the index to advertisements:

If you wish more information about any of the products or services mentioned in one or more of these advertisements, you may circle the appropriate CA No.'s on the Reader's Inquiry Form (see page 33), and send that form to us -- we pay postage (see the instructions). We shall then forward your inquiries, and you will hear from the advertisers direct.

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